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Comparison of Seismic Response between Flat Slab Building and Regular Frame Building

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***Abstract*— In today's world flat slab construction activity is growing due to many advantages it posses in terms of architectural flexibility, use of space, easier formwork and shorter construction time. From functional aspect a flat-slab RC frame building is more efficient than a beam-slab R.C. frame building. So, construction of flat-Slab building is increasing also in high seismic zone. In the present study, the seismic behaviour of flat slab building is carried out. For this purpose linear analysis of flat slab building and regular framed structure building has been carried out. The comparison shows that the flat slab buildings have low base shear capacity and large deflection. Also linear analysis of flat slab building with shear wall and regular framed structure building with shear wall has been carried out. It is found that the performance of flat slab building under seismic load improves much better with the use of shear wall.**

***Keywords*— "Flat Slab, Shear Wall, Equivalent Lateral Force Analysis, SAP 2000, Base Shear"**

I. INTRODUCTION

Flat slab system is being adopted in many buildings as they have major advantages over traditional slab-beam-column structures such as speedy construction, reduced floor heights to meet the economical and architectural demands, less loss of energy in cold storage buildings, simple formwork and more unobstructed space etc.

Flat slab system also known as a beamless slab is one in which RC slabs directly rests on columns without the agency of beams or girders and load from slab is directly transferred to column and then to the foundation. To take care of heavy shear and bending moment the portion of slab around the column is thickened. This thickened portion which is usually square or rectangular in plan is called as drop or drop panel. Also for this, columns are generally provided with enlarged heads called as column heads or capitals.IS456:2000 gives following two methods of analysis and design for flat slab system. One is direct design method and other is equivalent frame method.

Generally flat slabs are designed in lower seismic zone areas for gravity loads and due to absence of deep beams, flat slab structural system is significantly more flexible for lateral loads than traditional slab-beam-column frame system. Also the provision of ductile detailing of flat slab in IS code is not given separately. This makes the flat slab system more vulnerable under seismic events. For this purpose the study of flat slab buildings under seismic load is very important.

II. OBJECTIVES

In the present study, the seismic behaviour of flat slab building is carried out. For this purpose linear analysis of flat slab building and regular framed structure building has been carried out. The comparison shows that the flat slab buildings have low base shear capacity and large deflection. Also linear analysis of flat slab building with shear wall and regular framed structure building with shear wall has been carried out. It is found that the performance of flat slab building under seismic load improves much better with the use of shear wall.

III. MODELING AND ANALYSIS

To obtain and compare the seismic response of regular framed structure building, flat slab building, regular framed structure building with shear wall and flat slab building with shear wall different type of models are developed and analysis is carried out using SAP2000.

A. *Problem Data for Flat Slab Building and Regular Frame Building*

Type of frame:	Ordinary moment resisting frame
Seismic zone:	III
Number of storey:	4(G+3)
Size of bay:	6m*6m
Plan area:	24m*24m
Storey height:	3.6m
Plinth height above top of footing:	1.8m
Column:	450mm*450mm
Plinth beam:	300mm*450mm
Floor Finish:	$1kN/m^2$
Partition Load:	$2.5kN/m^2$
Live Load:	$3kN/m^2$
Live Load on terrace:	$1.5kN/m^2$

Materials:	Concrete M20, Steel Fe 415
Density of concrete:	$25kN/m^3$
Type of Soil:	Medium
Damping of structure:	5%
Elastic modulus of the masonry wall E_m :	$3000*10^6N/m^2$
Elastic modulus of the frame material E_f :	$22360N/m^2$

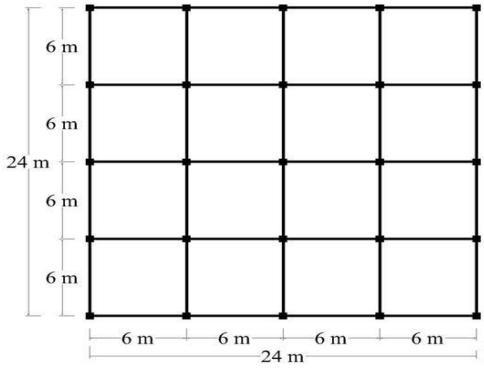

Fig. 1 Plan of flat slab building

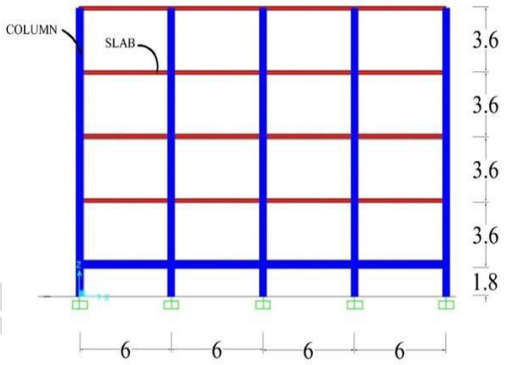

Fig.2 Elevation view of flat slab building

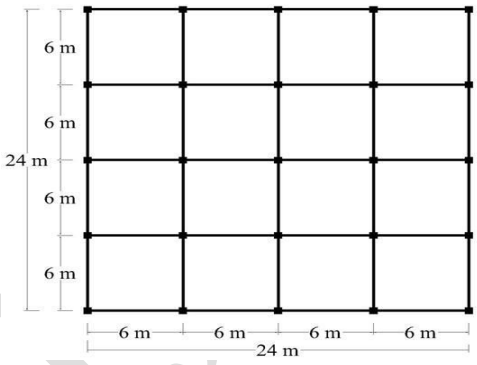

Fig. 3 Plan of regular frame building

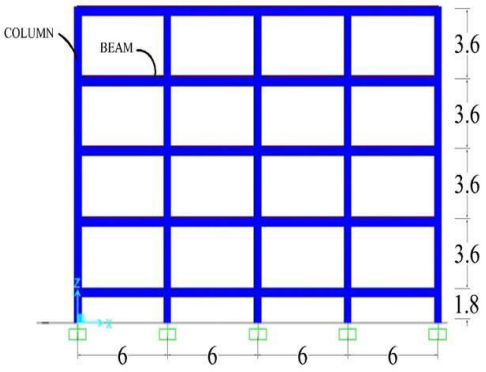

Fig. 4 Elevation view of regular frame building

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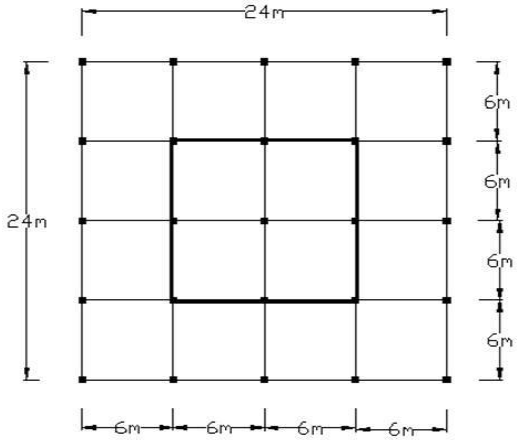

Fig. 5 Plan of flat slab building and regular frame building with shear wall at core

B. Flat slab building models

Description of building

A four storied flat slab building situated in Zone III, is taken for the purpose of study. The plan area of building is 24m x 24 m. with 1.8 m as height of plinth above top of footing and remaining stories having height as 3.6m. It consists of 4 bays of 6m each in X-direction and Y-direction. The building is considered as an ordinary moment resisting frame. Damping of structure is assumed as 5% of critical damping.

The various models of flat slab building that are modelled are as follows.

Table 1 Details of Flat slab building with no infill

Model	Slab Thick(mm)
F-1-0	200
F-2-0	230
F-3-0	250
F-4-0	280

Table 2 Details of Flat slab building with shear wall at core

Model	Slab Thick(mm)	Shear Wall Thick(mm)
F-1-S	200	218
F-2-S	230	216
F-3-S	250	214
F-4-S	280	213

Where,

F -Flat slab Building
1, 2, 3, and 4 in F-1, F-2, F-3 and F-4represents different slab thicknesses
O -Building with no infill
S -Building with shear wall at core

C. Regular Frame Building Models

Description of building

A four storied regular frame building situated in Zone III, is taken for the purpose of study. The plan area of building is 24m x 24 m. with 1.8 m as height of plinth above top of footing and remaining stories having height as 3.6m. It consists of 4 bays of 6m each in X-direction and Y-direction. The building is considered as an ordinary moment resisting frame. Damping of structure is assumed as 5% of critical damping.

The various models of regular frame building that are modelled are as follows.

Table 3 Details of Regular frame building with no infill

Model	Slab Thick(mm)	Beam Size(mm*mm)
R-1-O	143	300*450
R-2-O	168	300*500
R-3-O	175	300*600
R-4-O	186	300*750

Table 4 Details of Regular frame building with shear wall at core

Model	Slab Thick(mm)	Shear Wall Thick(mm)
R-1-S	143	218
R-2-S	168	216
R-3-S	175	214
R-4-S	186	213

Where,

R -Regular frame building
1, 2, 3, and 4 in R-1, R-2, R-3 and R-4 represents different slab thicknesses
O -Building with no infill
S -Building with shear wall at core

D. Step by Step Procedure of Analysis in SAP2000:

1) *Define Material Properties:* The material properties of concrete and steel are given. For concrete properties like weight per unit volume, modulus of elasticity poisons ratio and compressive strength must be given. For M20 grade, the above properties are 25kN/m3, 5000√fck, 0.15, 20000 kN/m^{2}respectively. For steel minimum yield strength is required and for Fe 415, it is 415000kN/m^2.

2) *Define Frame section properties:* The frame section properties of column size and beam size are given. For column and beam width and depth has given. For column the reinforcement details are clear cover, longitudinal and confinement bar size, number of longitudinal bars provided and confinement spacing should be given. For beam the reinforcement details are clear cover to top and bottom has given.

3) *Define Area section properties:* For slab the area section properties are given. Shell element is used for slab and thickness of slab is given.

4) *Developthe model and assign the joint restraints:*In this step, preparing model by adding frame objects and area objects with the associated column, beam and slab. Once the model is prepared next step is assigning joint restraints. For building frame the joint restraints is fixed joint.

5) *Define load pattern and assign to frame :* In this step, the load patterns like dead load, floor finish, live load are defined. The loading is given to the frame. The mass source is defined the all dead loads are considered 100% and live load must be considered as 25% (because live load = 3kN/m^2). Then all joints are making rigid by joint constraints. The loading combinations are given.

6) *Run the Analysis:* The value for shear force and bending moment for every element must be check. The design check for column must be taken i.e. the reinforcement provided are sufficient or not.

IV. RESULTS AND DISCUSSION

In this section all the models of flat slab buildings and regular frame buildings are analyzed by equivalent lateral force method as per IS 1893 part-1 using SAP2000. The results obtained for flat slab buildings and regular frame buildings are shown below.

A. Results of Flat Slab Building Models

Table 5 Results of Flat slab building with no infill:

Model	Base shear (kN)	Period T (sec)	Disp.(mm)
F-1-0	412.15	2.23	33.40
F-2-0	489.43	2.05	29.29
F-3-0	540.71	1.97	27.24
F-4-0	596.97	1.93	25.89

Table 6 Results of Flat slab building with Shear wall at core

Model	Base shear (kN)	Period T (sec)	Disp.(mm)

F-1-S	1786.66	0.20	1.13
F-2-S	1889.47	0.21	1.20
F-3-S	1972.90	0.21	1.30
F-4-S	2078.00	0.22	1.30

B. Results of Regular Frame Building

Table 7 Results of Regular frame building with no infill

Model	Base shear (kN)	Period T (sec)	Disp.(mm)
R-1-0	737.28	1.13	17.51
R-2-0	825.06	1.08	16.47
R-3-0	921.65	1.01	15.01
R-4-0	1034.00	0.96	13.87

Table 8 Results of Regular frame building with Shear wall at core:

Model	Base shear (kN)	Period T (sec)	Disp.(mm)
R-1-S	1692.93	0.19	1.03
R-2-S	1801.93	0.20	1.10
R-3-S	1879.19	0.21	1.12
R-4-S	2027.28	0.22	1.20

C. Observations by Equivalent Lateral Force Analysis

Flat slab building having same mass as that of the regular frame building gives less base shear and more disp. For example, for model F-1-O V_b=412.15 kN and disp. = 33.40 mm, for model R-1-O V_b=737.28 kN and disp. = 17.51 mm.

V. CONCLUSSION

Study of different models for seismic loads, by equivalent static analysis of flat slab and regular frame building gives,

i. Performance of regular frame building is better than flat slab building.
ii. Performance of flat slab building improves much more with the use of shear wall.

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